Site Need Statement

General Reference Information	
1 *	***Need Title:*** Double-Shell Tank (DST) Corrosion Monitoring
2 *	***Need Code:*** RL-WT004
3 *	***Need Summary:*** Corrosion monitoring of double-shell tanks (DSTs) is currently provided by process knowledge and tank sampling. Tanks found to be within chemistry specification limits are considered to be not at risk for excessive corrosion damage. There have been no direct corrosion monitoring systems for DSTs in use at the Hanford Site. However, maintaining DST wastes within chemistry limits has been problematic. Ultrasonic examination of DSTs through FY 2001has gathered a growing body of evidence of material behavior under actual tank operating conditions. In some cases, these data appear inconsistent with the laboratory data that formed the basis for the waste chemistry specifications. Tank samples are infrequent and their analysis difficult and expensive. Waste streams that are exempt from the corrosion control specifications complicate process knowledge. In-tank, real-time measurement of the corrosive characteristics of the tank wastes is needed to improve control of corrosion processes. Recent ultrasonic examinations of DSTs indicated corrosion near the waterline in the form of pits (e.g., 101-AY, 102-AN). Such waterline corrosion is a result of a lack of adequate hydroxide concentration near the waste surface due to a reaction between carbon dioxide in the dome space air and hydroxide in the waste. The decrease in hydroxide concentration translates to a decrease in the pH of the waste near the waterline. It has been well known that at pH values less than 10, the carbon steel wall of the DSTs is prone to pitting attack. A decrease in pH could also occur underneath the waste surface in the supernatant and the sludge due to consumption of hydroxide by organics. Therefore, knowledge of pH of the waste is extremely beneficial in mitigating corrosion of the tank wall and extend its life. Probes to measure pH instantaneously in various environments are routinely used in the process industry. Probes with glass electrodes are usually limited for use in solutions with low ionic strength. The Hanford DSTs contain wastes with very high ionic strength and, therefore, the development of pH probes that can measure pH in very high ionic strength environments is needed. These probes, once developed, could be initially installed in the caustic deficient tanks to monitor the pH. The probes should be placed near the waste surface, in the supernatant and in the sludge. For use near the waste surface, a floating probe needs to be developed. These pH probes should also be able to withstand the high radiation environment of the DST wastes. This technology need also requires that the probes be designed of readily available materials that would lead to economic production of a large number of pH probes for installation in every DST. Therefore, this need calls for the implementation of a 1-year laboratory study for the design and development of a pH probe for use in high ionic strength and high radiation environments with additional time needed for deployment in the DSTs. This is a corrosion control issue and will affect all of the dilute waste storage tanks at Hanford, and may ultimately impact all 28 DSTs.
4 *	***Origination Date:*** FY 2000 (March 1999)
5 *	***Need Type:*** Technology Need
6	***Operation Office:*** Office of River Protection (ORP)
7	***Geographic Site Name:*** Hanford Site
8 *	***Project:*** Safe Storage/Tank Farm Operations ***PBS No.:*** RL-TW03
9 *	***National Priority:*** _X_ 1. High - Critical to the success of the EM program, and a solution is required to achieve the current planned cost and schedule. ___2. Medium - Provides substantial benefit to EM program projects (e.g., moderate to high life-cycle cost savings or risk reduction, increased likelihood of compliance, increased assurance to avoid schedule delays). ___3. Low - Provides opportunities for significant, but lower cost savings or risk reduction, may reduce the uncertainty in EM program project success.
10	***Operations Office Priority:*** High

Problem Description Information	
11	***Operations Office Program Description:*** The overall purpose of the safe-storage function is to operate and maintain the double shell tank (DST) and single shell tank (SST) farms in a safe and compliant manner until the contained wastes are retrieved and the tank farms are ready for closure. This includes performing day-to-day operations, maintaining and upgrading infrastructure, resolving safety issues, assessing tank integrity, characterizing the waste, and managing the DST waste inventory. This function also includes interim stabilization of selected SSTs. The end state of safe storage is containment of DST and SST tank wastes in a manner that supports safe waste retrieval for final waste disposal; tank-farm structures, including DSTs and SSTs, ready for final disposal and closure; and tank farms amenable and ready for the mitigation of any environmental releases that occurred during storage and retrieval of tank waste.
12	***Need/Problem Description:*** Corrosion control of high-level waste DSTs is currently provided by concentration limits on hydroxide, nitrite, and nitrate. Monitoring of the chemistry is provided by tank samples and process knowledge. As many as 4 DSTs at Hanford have operated outside of corrosion chemistry limits in recent years. Detection and remediation of these low hydroxide tanks has been slow and costly. Two of these tanks were brought into compliance during FY 2001. The remaining two are scheduled to be brought into compliance during FY 2002. Available technology for corrosion monitoring has progressed to a point where it is now feasible to monitor and control corrosion by on-line monitoring of the corrosion process and direct addition of corrosion inhibitors. Progress toward meeting this need has been made through the deployment of electrochemical noise probes in five Hanford tanks. These probes have generated data that improve insight to the extent and type of corrosion processes occurring as chemistry in the tank waste is adjusted. Additional work is needed to validate the conclusions and interpretation of data and to upgrade probe design for extended life. The potential benefits of a corrosion monitoring system include: 1. Safer operation and reduced risk of primary tank failure, due to more timely identification and resolution of corrosivity conditions. Corrosion will be monitored directly, versus monitoring chemical species. Assumptions about tank waste homogeneity and accuracy of the corrosion chemistry specification will be reduced or removed. *2.* Avoidance of unnecessary chemical additions: An estimated 100 to 200 metric tons of sodium, in the form of sodium hydroxide, will be added to the four double-shell tanks that are/were noncompliant with corrosion control specifications. Approximately $7.5 million has been budgeted in FY 2001 and FY 2002 to bring the four tanks into compliance (in comparison, approximately $500 thousand has been budgeted in FY2001 and FY 2002 for corrosion probe installation and monitoring). Also, because sodium may be a controlling constituent for production of vitrified waste, addition of sodium hydroxide for corrosion control during waste storage may result in higher downstream costs for production and disposal of higher numbers of HLW canisters. Quantification of this potential cost impact awaits process flow development by the vitrification contractor. Direct monitoring of the actual tank corrosion conditions can potentially eliminate or reduce addition of sodium hydroxide to waste storage tanks for corrosion control. Corrosion control of DSTs is accomplished by operating the tanks within the corrosion chemistry specifications at pH in the range 11-13. Monitoring the chemistry of tank waste is performed using process knowledge and tank sampling. Tank samples are taken infrequently and their analysis is difficult and expensive. Process knowledge is complicated because of waste streams (notably line flushes and process condensate recycle) that are exempt from the corrosion control specifications. As tank waste chemistries change and hydroxide gets consumed, the waste becomes more aggressive toward tank steel wall. Tanks found to be within chemistry specification limits with a pH in the range of 11-13 are considered to be not at risk for excessive corrosion damage. However, four DSTs are currently operating with low hydroxide (out of corrosion specification) concentration, probably at a pH lower than the required range. Installation and operation of a properly designed pH probe will give an instantaneous indication of the pH of the tank waste and alert the tank farm operations if a corrective action such as caustic addition is needed. Therefore, a pH probe needs to be designed and deployed in the DSTs to continuously monitor the constantly changing

       ** ** **	chemistry conditions that lead to a lowering of pH below the required range. ***Consequences of Not Filling Need:*** <u>Regulatory Impacts</u> Waste compatibility is one area that must be addressed in tank system integrity assessments, per Washington Administrative Code (WAC) Dangerous Waste Regulations (WAC 173-303-640). There are no current regulatory requirements explicitly requiring deployment and monitoring of corrosion probes. However, Administrative Orders 00NWPKW-1250 and 00NWPKW-1251 issued by the Washington State Department of Ecology against DOE and the tank farm contractor require that corrosion probe data be incorporated into the DST System Integrity Assessment Report due in March 2006. <u>Programmatic Impacts</u> Process knowledge and tank sampling currently provide corrosion control of double-shell tanks. Tank samples are infrequent and their analysis difficult and expensive. Waste streams that are exempt from the corrosion control specifications complicate process knowledge. In-line, real-time measurement of the corrosive characteristics of the tank wastes will augment the current system to provide an enhanced level of corrosion control information and allow a more rapid response to adverse conditions. Data from corrosion monitoring supports estimation of remaining tank life and therefore supports Technology Insertion Point (TIP) milestone T03-05-300, "Assess Need for DST Replacement," due April 2005. **Program Baseline Summary (PBS) No.:** RL-TW03 **Work Breakdown Structure (WBS) No.:** 5.01.03.05 **TIP No.:** T03-05-300, "Assess Need for DST Replacement," April 2005, and T03-01-300, "On-Line Monitoring for Waste Tank Corrosion Control," June 2001 (new date proposed: September 2003)
13	***Functional Performance Requirements:*** • Identify waste chemistry conditions that are conducive to stress corrosion cracking (SCC). • Identify waste chemistry conditions that are conducive to pitting. • Order of magnitude quantification of mass loss during pitting and cracking. • Quantification of uniform corrosion rates • Conduct laboratory testing to better understand EN signals associated with SCC and pitting. • Quantification of pH over the range of chemistry conditions in DSTs
**	**Schedule Requirements:** Work is to be completed by Fiscal Year 2002.
14	***Definition of Solution:*** The successful solution will provide real-time data on tank waste corrosivity, including conditions conducive to SCC and pitting.
15 *	***Targeted Focus Area:*** Tanks Focus Area (TFA)
16	***Potential Benefits:*** TBD
17 *	***Potential Cost Savings:*** TBD
18 *	***Potential Cost Savings Narrative:*** The principal potential cost benefit of corrosion monitoring may be lower processing and disposal costs, resulting from elimination or reduction of sodium hydroxide addition to waste storage tanks for corrosion control. Quantification of this cost benefit depends on further development of the process flowsheet by the vitrification contractor. There is also the potential of lower costs for bringing tanks into compliance with the chemistry specifications if it can be shown by direct corrosion monitoring that less caustic need be added. There is an additional, though unquantified, cost benefit resulting from reduced uncertainty associated with understanding of corrosion processes in Hanford's DSTs. Improved understanding of corrosion processes leads to better decisions on managing risk of DST failure, including actions taken to prolong tank life, and decisions on tank replacement. The existing operating specification for DSTs prescribes waste chemistry requirements for the purpose of limiting corrosivity, and prolonging tank life. The DSTs will be needed well beyond their design life to support the future waste retrieval and treatment missions at the Hanford Site. Construction of new waste storage tanks could be required if remaining tank life is projected to fall short of the projected River Protection Project (RPP) mission duration. The estimated cost to build a new 6-tank farm (Multi-Function

	Waste Tank Facility) was $435 million in 1993 dollars. It is difficult to quantify the benefit (in dollars) of knowing the pH conditions of the DST wastes. However, it is clear that decisions on corrosion inhibitor addition and DST replacement have the potential to significantly impact RPP life cycle costs in the range of 100s of millions of dollars. Continuous monitoring of DST waste chemistry by a pH probe and responding with a corrective action (e.g., caustic addition to tank waste) when needed would be a good justification for those decisions.
**	***Technical Basis:*** Real-time corrosion monitoring has been selected for preliminary evaluation at the Hanford Site. The use of such a system in Hanford waste tanks would allow for real-time monitoring of both corrosion processes and corrosion inhibitor addition. Real-time data collection would facilitate identification of the precise time when a corrosion process begins to occur in a tank. This, coupled with corrosion rate information also generated, would help in determining the extent of design life lost due to degradation by abnormal corrosion conditions. Similarly, real-time corrosion monitoring during inhibitor addition would allow one to observe corrosion conditions return to an acceptable level. Therefore, unnecessary inhibitor addition could be eliminated. The current system cannot offer this capability. Available techniques offer the ability to distinguish between uniform corrosion, stress corrosion cracking, pitting, and other forms of localized corrosion as they occur. They also generate uniform corrosion rate data identical to what is currently derived from chemical sampling. Some available corrosion monitoring techniques using electrical resistance probes or linear polarization resistance probes are not capable of distinguishing between uniform and localized forms of corrosion. These would not be considered acceptable. The most likely cause of failure in DSTs is degradation due to some form of localized corrosion. It has been well known that at pH values less than 10, the carbon steel wall of the DSTs is prone to pitting attack. Hydroxide concentration near the waste surface is continuously depleted due to a reaction between carbon dioxide in the dome space air and hydroxide in the waste. The decrease in hydroxide concentration translates to a decrease in the pH of the waste near the waterline. A decrease in pH could also occur underneath the waste surface in the supernatant and the sludge due to consumption of hydroxide by organics. Therefore, knowledge of pH of the waste is extremely beneficial in mitigating corrosion of the tank wall and extend its life. RPP-8173, Rev. 1 *Technical Basis for Caustic Additions to Tanks 241-AN-102, 241-AY-101, 241-AY-102, and 241-AN-107*- DRAFT, discusses the principle corrosion mechanisms (uniform corrosion, pitting, and stress corrosion cracking) that play an active role in DST primary wall corrosion and provides estimates of remaining useful lives for these tanks. BNL-52527, *Guidelines for Development of Structural Integrity Programs for DOE High-Level Waste Storage Tanks*, discusses the important role of corrosion monitoring in the context of a comprehensive structural integrity program. DOE-STD-1073-93, *Configuration Management*, requires implementation of a Material Condition and Aging Management Program to control aging processes in major equipment and components. The primary aging processes in waste tank systems are corrosion related. DOE/RL-92-60, *Tank Waste Remediation System Functions and Requirements* contains corrosion control requirements for the Store Waste (F4.2.1.1) and Transfer Waste (F4.2.4.4) functions.
19	***Cultural/Stakeholder Basis:*** Maintaining DST integrity is a major issue of concern with the Washington State Department of Ecology and Hanford Stakeholders. This concern is reflected in Tri-Party Agreement milestones, review of the RPP EIS, and in other public documents.
20	***Environment, Safety, and Health Basis:*** HNF-SD-WM-TSR-006, *Tank Farms Technical Safety Requirements*, Administrative Control 5.15, *Chemistry Control Programs*. This document contains operational safety requirement - administrative controls for corrosion control, cathodic protection, and integrity assessments. Implementation of these administrative controls necessitates corrosion control activities.

	DOE Order 5820.2A, *Radioactive Waste Management*, requires monitoring of cathodic protection systems, methods for periodically assessing waste storage system integrity, and adjustment of waste chemistry to control corrosion. HNF-SD-WM-OCD-015, *Tank Farm Waste Transfer Compatibility Program*, describes decision rules relating to waste transfers into and within the DST system. The document defines a means of consistently applying safety, operational regulatory and programmatic criteria and specifies considerations necessary to assess waste transfers.
21	***Regulatory Drivers:*** *Washington Administrative Code* 173-303-640(2)(c)(iii) requires consideration of existing corrosion protection when performing tank system integrity assessments. On-line corrosion monitoring may provide an acceptable performance measurement of current corrosion protection measures and early warning of potentially corrosive conditions. Administrative Orders 00NWPKW-1250 and –1251, issued by the Washington State Department of Ecology, require incorporation of corrosion probe data into the DST System Integrity Assessment Report, due March 2006 (Section 12).
22 *	***Milestones:*** (Draft) TPA Milestone M-48-14 requires completion of the DST System Integrity Assessment Report (including consideration of corrosion probe data) by March 31, 2006. Technology Insertion Point (TIP) milestone requires assessing the need for DST replacement by April 30, 2005.
23 *	***Material Streams:*** Tanks and Residuals, HLW-HANF-3 (Double Shell Tanks), Sludge, salt, liquid (RL-HLW-20)
24	***TSD System:*** Double Shell Tanks
25	***Major Contaminants:*** Pu-238, 239, 240, 241; Am-241; U-238; C-14; Ni-59/63; Nb-94; Tc-99; I-129; Cm-242; Sr-90; Cs-137; Sn-126; Se-79; chromium; nitrate; nitrite; complexants (EDTA/HEDTA).
26	***Contaminated Media:*** Tank waste consisting of supernate (liquid), salt cake, and sludge. For details, see, e.g., B. M Hanlon, "Waste Tank Summary Report for Month Ending June 30, 2001," HNF-EP-0182, Rev. 159, (CH2M HILL Hanford Group, Inc., Richland, WA, July 2001).
27	***Volume/Size of Contaminated Media:*** All double shell tanks are 75 feet in diameter, and about 40 feet deep, with their tops buried about 10 feet below the ground surface. They are generally about a million gallons in volume.
28 *	***Earliest Date Required:*** January 2003
29 *	***Latest Date Required:*** September 2004
Baseline Technology Information	
30	***Baseline Technology/Process:*** There is no baseline technology for direct monitoring of corrosion in high-level waste tanks. Technology Insertion Point: T03-05-300, "Assess Need for DST Replacement," April 2005, and T03-01-300, "On-Line Monitoring for Waste Tank Corrosion Control," June 2001 (new date TBD)
31	***Life-Cycle Cost Using Baseline:***
32	***Uncertainty on Baseline Life-Cycle Cost:***
33	***Completion Date Using Baseline***.
Points of Contact (POC)	
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*Element of a Site Need Statement appearing in IPABS-IS
** Element of a Site Need Statement required by CHG